CHAPTER 6

Monitoring and Evaluating Pesticide Exposure

Many pesticides are toxic to human beings and practically all are capable of causing some type of damage or injury if improperly handled.
– 1950 Department annual report

Exposure Assessment and Mitigation

Exposure is the critical connection between potentially harmful factors of substances like pesticides (as determined in the hazard identification phase of risk assessment, *see Chapter 5*) and human health effects. Exposure assessment is designed to estimate what exposures are experienced under differing use conditions. Exposure assessment requires estimating the concentration of a substance to which humans are exposed, the size of the population exposed, the nature of the exposed population (e.g., activity, age, occupation, special risk characteristics), and the duration and frequency (continuous or varied) of exposure. These assessments estimate exposures for various subpopulation groups, including pesticide handlers, field workers, consumers exposed to pesticides in the home and garden, and bystanders, particularly infants, children and other susceptible subgroups.

DPR conducts risk assessments of pesticides to determine the potential risks of pesticide exposures in occupational settings and community environments to pesticide handlers, farm workers, other pesticide users (e.g., persons using home-and-garden products), bystanders (persons near treated areas), and others who may be exposed (e.g., by entering treated areas, or by eating treated food). If unacceptable risks are identified, DPR determines whether they can be mitigated, that is, if use practices can be changed to reduce exposure to ensure safe pesticide use. Exposure assessments — as part of a complete risk characterization — are the basis for determining if existing safety measures are adequate. If inadequate, these documents may be a starting point for developing mitigation measures, such as engineering controls (e.g., closed tractor cab), administrative controls (e.g., restricted entry intervals), or personal protective equipment (e.g., rain suit, gloves). If use practices cannot be changed to adequately reduce exposure, DPR may eliminate use of the pesticide.

Worker Health and Safety (WH&S) Branch scientists review a wide variety of data, including toxicology studies (done primarily on animals), human exposure studies, pesticide use data, worker activity information, and crop statistics to calculate potential exposure for a variety of scenarios. To determine the dietary component of a risk assessment, Medical Toxicology Branch scientists review data to determine potential residues on and in food and dietary water. *(See separate article in this chapter on dietary risk assessment.)*

Exposure assessments begin with an evaluation of the physical and chemical characteristics of a pesticide. WH&S Branch scientists evaluate whether pesticide breakdown products (e.g., metabolites) occur, potential routes of exposure (e.g., dermal, inhalation, oral), the half-life of the chemical, and other properties as part of the assessment. WH&S scientists also evaluate pesticide product labeling and pesticide use data to identify pesticide use sites (e.g., crops, industrial uses, garden uses, indoor home uses) and application methods (e.g., hand-held sprayer, ground sprayer, aerial application) to characterize the exposure scenarios. In addition, scientists review pesticide labels to determine application rates and frequencies, preharvest intervals, restricted entry intervals and personal protective equipment. To calculate exposures, scientists consider the timing, frequency and duration of various worker activities relative to the pesticide application. WH&S Branch scientists also review pesticide illness and injury data to identify potential health problems attributed to exposure to the pesticide.

WH&S scientists prefer to use chemical-specific and activity-specific exposure data to derive exposure estimates for the risk assessment process. If such data are not

available, scientists use data from surrogate studies or from the Pesticide Handlers Exposure Database (PHED), developed by Health Canada, U.S. EPA, and the American Crop Protection Association. PHED is a generic (not product-specific) pesticide worker exposure database containing measured values of dermal and inhalation exposures from dozens of field studies.

Scientists consider the likely routes of exposure, primarily inhalation of air containing dusts and vapors, skin (dermal) contact either with the pesticide directly spilled on skin or contact with foliage, soil, or other surfaces (e.g., household furniture, carpets) on which residues may be present, and ingestion of foods and water with pesticide residues. Depending on the chemical and physical properties of the substance, a particular exposure might not be considered significant; for example, a given chemical might not be absorbed by the body when spilled on the skin (because of a very low dermal absorption rate) but may be absorbed when present in drinking water. Exposure to a chemical, therefore, is not necessarily synonymous with the actual amount of the chemical absorbed by body fluids and tissues. Exposure assessments estimate an absorbed (internal or systemic) dosage from which a margin of safety and other risk estimates can be derived. It is the absorbed dose that usually determines the margin of safety (and thus any mitigation measures that might be necessary), although if there are significant irritant effects (for example, eye irritation), they could be the driving factor in any regulatory measures.

Traditionally, pesticide exposure assessments use conservative (that is, health-protective) single-point values for chemical concentrations, application frequency and rate, duration of contact, calculation of internal dose, and body weight to characterize the exposure scenarios. Characterizing these exposure variables in terms of their probable ranges yields a more realistic estimate of the exposure. This approach is generally referred to as probabilistic modeling, or Monte Carlo simulation. Instead of presenting a single point estimate of risk, probabilistic analyses characterize a range of potential risks and their likelihood of occurrence. In addition, those factors which most affect the results can be easily identified. WH&S Branch uses computer software that enables scientists to perform probabilistic simulations in pesticide exposure assessments. Such data — and continually evolving scientific techniques — form the basis for the detailed exposure assessments prepared by WH&S Branch.

The rapid increase in the use of synthetic organic chemicals illustrates the need for study to provide data for intelligent handling of products of this nature.... Possible industrial health hazards of new products should be anticipated. Problems as to hazards to workers not only in mixing of chemicals but to those who make field applications constantly arise. When a chemical is not acutely poisonous, generally little is known of the extent of its injuriousness. Information should be at hand with regard to insidious chronic poisoning by newly developed materials, as well as to their acute toxicity....
– 1939 Department annual report

Exposure Monitoring Program

Assessing human exposure requires a wide and varied base of knowledge involving work tasks, application methods, application scenarios, and other circumstances. Each year, WH&S scientists conduct unique human exposure monitoring studies to provide data for the risk assessment process. Through these studies, scientists continually improve data collection methods, and more accurately predict likely exposures.

The scientists in the exposure monitoring program devote themselves to extending and refining DPR's understanding of the mechanisms of exposure. The scientists in this program monitor a variety of activities, such as mixing and loading, application by hand, by ground or air, worker reentry into treated fields, and structural fumigations. In each situation, the goal is to identify factors influencing the degree of exposure, as well as to measure exposure.

A variety of methods are used to develop data. Clothing worn by workers performing routine tasks is collected and analyzed to determine residue levels and estimated dermal exposure. This information identifies factors affecting transfer of a pesticide from foliage to work clothing or skin, or determines the effect of various application methods on worker exposure. In addition, urine and blood samples may be collected and analyzed for biological indicators of exposure. Goals include providing better estimates of worker exposure, evaluating mitigation measures, developing new monitoring methods, and validating new and established monitoring methods. All studies involving human subjects require formal protocols approved by an independent, University of California human subjects review committee.

The WH&S exposure monitoring scientists also collect data on the amount of pesticide residue deposited on plants following various application methods and rates.

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Dietary Risk Assessment

DPR's Medical Toxicology Branch assesses the safety of pesticides by looking at all routes of exposure to residues at work, in the home, and in the diet.

Dietary risk from pesticide exposure is estimated by:

1. looking at how toxic or harmful a pesticide might be *(see discussion on hazard identification, in Chapter 5);*
2. looking at the amount of pesticide residues that might be in or on food; and
3. looking at how much food might be eaten by various subpopulation groups.

Estimating how much residue might be in or on food involves several things. If the pesticide is used on food, studies determine how much of the pesticide is typically left after the chemical is applied to the crop in the field and then harvested. In addition, the U.S. Food and Drug Administration, U.S. Department of Agriculture, and DPR all have programs in which they collect random samples of fresh produce and test for residues in the laboratory. The U.S. FDA and USDA also test for residues in cooked and processed foods.

USDA does nationwide surveys every several years to estimate the kinds and amount of food that people eat. Food consumption is reported for people of different races and ethnic groups, age groups, genders, geographical regions, and seasons of the year. The consumption rate is expressed in terms of body weight and accounts for a potential higher intake by children, as compared to adults, on a per weight basis.

The next step in estimating dietary exposure is to multiply the amount of food that people eat with the residues that might be found on those foods. These dietary exposure estimates are combined with the toxicity data to assess the risk to various population subgroups, including infants and children, from the exposure to pesticide residues in food. The resulting information on dietary risk is then included in an overall assessment of the risk posed by the pesticide for all uses.

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These data characterize residue decay rates that may differ under varying environmental conditions. This information may be critical in determining potential worker exposures and is used in developing techniques for avoiding illness and injury.

WH&S scientists also assist County Agricultural Commissioners in the investigation of some pesticide-related illnesses and injuries. With adequate notice following an exposure incident, scientists can collect samples and interview workers to determine the cause and extent of exposure. These types of investigations are essential in making determinations of workplace safety.

WH&S scientists investigate the effectiveness of protective clothing, gloves, respirators, engineering controls (e.g., closed mixing systems for preparing pesticides for application, enclosed cabs) and other safety equipment in mitigating exposures. For example, recent work has demonstrated that enclosed cabs with air filters are effective in providing respiratory protection. With the implementation of the U.S. EPA Worker Protection Standard, this information is translated into regulatory language that will encourage use of the most protective equipment.

In addition to evaluating the effectiveness of mitigation strategies, exposure monitoring studies may be used directly for regulatory purposes. Setting reentry intervals, determining required protective gear, and developing safe handling practices rely upon accurate information about pesticide behavior in the field.

DPR's Pesticide Workplace Evaluation Program is designed to help County Agricultural Commissioner staff identify potential workplace hazards during their routine inspections.

Workplace Evaluation Program

DPR established the Pesticide Workplace Evaluation Program (PWEP) in 1999. Its objective is to help County Agricultural Commissioner staff identify potential workplace hazards during their routine inspections for compliance with pesticide laws and regulations. PWEP provides selected county inspectors and DPR Enforcement staff with training in industrial hygiene and occupational safety. WH&S scientists then work closely with the counties to evaluate hazards identified through this program and recommend changes to improve workplace safety.

WH&S Branch's Workplace Evaluation & Industrial Hygiene Program also evaluates pesticide products, pesticide-handling equipment, and labeling for effectiveness of exposure hazard control. Scientists in this program recommend control methods, when needed, to ensure adequate protection to the pesticide product user and others possibly exposed to pesticides. Evaluation includes review of federal product labels, hazard communication literature (MSDS), application worksite evaluations, and onsite compliance monitoring. Scientists work with other DPR groups, professional engineering and governmental occupational safety and health organizations to develop mitigation measures applicable to pesticide use. Recommended control methods are based on established industrial hygiene hierarchy of control. Scientists consult on matters of engineering controls, administrative controls, heat stress, personal protective equipment, and airborne monitoring methods.